CLAIMS

1. A clamping device for clamping a workpiece between a clamping arm and an opposed clamping member by rotating the clamping arm supported for rotating on a body and applying a clamping force to the clamping arm, the device comprising:

a worm to be driven for rotation about an axis on the body;

a worm wheel provided to a periphery of a rotating shaft of the clamping arm and engaged with the worm; and

a clamping force applying mechanism to be actuated in response to contact of the clamping arm with the workpiece supported by the clamping member to apply an axial force in a direction of the axis to the worm rotation of which has been stopped by the contact, wherein

the clamping arm is rotated by driving of the worm for rotation and

the axial force applied to the worm by the clamping force applying mechanism acts on the worm wheel as a pressing force in a direction of a tangent to the worm wheel to apply the clamping force to the clamping arm.

2. A clamping device according to claim 1, wherein the worm is provided for reciprocation between an initial position and a clamping force transmitting position on the axis and

the clamping force applying mechanism applies the axial force toward the initial position to the worm which has been displaced from the initial position to the clamping force

transmitting position by a reaction force from the worm wheel generated by a clamping operation of the clamping arm.

3. A clamping device according to claim 2, wherein the worm is elastically supported toward the initial position by a support spring disposed on the same axis and

the worm is displaced from the initial position to the clamping force transmitting position against the support spring by the reaction force from the worm wheel generated by the clamping operation of the clamping arm.

4. A clamping device according to claim 3, wherein the support spring is a disc spring.

5. A clamping device according to claim 1, wherein the clamping force applying mechanism includes a spring member disposed on the axis and applies a spring force of the spring member to the worm as the axial force.

6. A clamping device according to claim 5, wherein the spring member is the disc spring,

a "flexure-spring force" characteristic curve of the disc spring includes a region in which the spring force is substantially constant with respect to flexure variation, and the spring force in this region is applied to the worm as the axial force.

7. A clamping device according to claim 1 and further comprising:

a driving shaft supported for rotation about the axis and for sliding in a reciprocating manner in the direction of the axis on the body;

a driving source for applying a driving force about the axis and a driving force in the direction of the axis to the driving shaft; and

a driving force switching mechanism disposed between the driving source and the driving shaft to switch the driving force to be transmitted to the driving shaft from the driving source from the driving force about the axis to the driving force in the direction of the axis in response to the contact of the clamping arm with the workpiece, wherein

the worm is provided to a periphery of the driving shaft,

the driving force switching mechanism transmits the driving force about the axis to the driving shaft to drive the worm for rotation with the driving shaft in rotating of the clamping arm,

a power train including the driving source, the driving shaft, and the driving force switching mechanism forms the clamping force applying mechanism in response to the contact of the clamping arm with the workpiece, and the driving force switching mechanism transmits the driving force in the direction of the axis to the driving shaft rotation of which has been stopped by the contact of the clamping arm to thereby apply the axial force to the worm.

8. A clamping device according to claim 7, wherein the driving force switching mechanism is formed of a flange portion fixedly provided to the periphery of the driving shaft and formed with a first friction face on an end face of the flange portion and a gear nut which is formed with cogs on an outer periphery of the gear nut and is formed with a second friction face to be brought in contact with and separated from the first friction face on an end face of the gear nut, the driving force from the driving source being transmitted to the cogs,

the gear nut is screwed over the driving shaft with the second friction face facing the first friction face and is supported for rotation about the axis on the body,

the driving force switching mechanism brings the first friction face of the flange portion and the second friction face of the gear nut in contact with each other to transmit the driving force about the axis to the driving shaft in rotating of the clamping arm, and

the driving force switching mechanism screw-feeds the driving shaft rotation of which has been stopped by the contact of the clamping arm in the direction of the axis with the gear nut in response to the contact of the clamping arm with the workpiece to thereby separate the first friction face from the second friction face and transmit the driving force in the direction of the axis to the driving shaft.

9. A clamping device according to claim 7, wherein the worm is fitted over the driving shaft for sliding in a reciprocating

manner between an initial position and a clamping force transmitting position in the direction of the axis and is fixed about the axis to be displaced from the initial position to the clamping force transmitting position by a reaction force from the worm wheel generated by a clamping operation of the clamping arm and

the driving shaft is provided with an engaging portion for pressing the worm which has been displaced to the clamping force transmitting position toward the initial position with the driving force in the direction of the axis to apply the axial force to the worm.

10. A clamping device according to claim 9, wherein the clamping force applying mechanism includes a spring member disposed between the worm and the engaging portion,

the spring member is compressed by the driving force in the direction of the axis and transmitted to the driving shaft, and a spring force of the compressed spring member is applied to the worm as the axial force.

11. A clamping device according to claim 10, wherein the spring member is a disc spring,

a "flexure-spring force" characteristic curve of the disc spring includes a region in which the spring force is substantially constant with respect to flexure variation, and the spring force in this region is applied to the worm as the axial force.

12. A clamping device according to claim 9, wherein the worm is elastically supported toward the initial position by a support spring disposed between the engaging portion of the driving shaft and the worm and

the worm is displaced from the initial position to the clamping force transmitting position against the support spring by the reaction force from the worm wheel generated by the clamping operation of the clamping arm.

13. A clamping device according to claim 12, wherein the support spring is a disc spring.

14. A clamping device according to claim 7, wherein the driving source is an electric motor.

15. A clamping device according to claim 1, the device further comprising:

an arm rotating driving source for driving the worm for rotation;

a clamping force generating driving source provided to the clamping force applying mechanism independently of the arm rotating driving source so as to actuate the clamping force applying mechanism; and

a contact sensor for detecting the contact of the clamping arm with the workpiece to output a signal for causing the clamping force generating driving source to operate, wherein

the clamping force generating driving source is caused

to operate by the output signal from the contact sensor to actuate the clamping force applying mechanism to thereby apply the axial force to the worm.

16. A clamping device according to claim 15, wherein the arm rotating driving source is an electric motor and the clamping force generating driving source is an electromagnetic driving device utilizing an electromagnetic attracting force.

17. A clamping device according to claim 15 and further comprising a driving shaft supported for rotation about the axis and for sliding in a reciprocating manner in the direction of the axis on the body and connected to the arm rotating driving source, wherein

the worm is fixedly provided to a periphery of the driving shaft to be able to reciprocate between an initial position and a clamping force transmitting position on the axis and

the clamping force applying mechanism applies the axial force toward the initial position to the worm which has been displaced from the initial position to the clamping force transmitting position by a reaction force from the worm wheel due to a clamping operation of the clamping arm.

18. A clamping device according to claim 17, wherein the clamping force applying mechanism includes the clamping force generating driving source, a spring member disposed on the axis, a plunger to be reciprocated in the direction of the axis by operation

of the clamping force generating driving source, a sliding shaft passing through a center of the spring member and having one end fixed to the plunger and the other end formed with a shaft head portion with which one end of the spring member is in contact, and a spring seat with which the other end of the spring member is in contact and which supports the sliding shaft for sliding in the direction of the axis, the spring member being compressed between the shaft head portion and the spring seat by reciprocation of the plunger, wherein

the clamping force generating driving source operates in response to the output signal from the contact sensor and, as a result, the shaft head portion presses the driving shaft in the direction of the axis with the spring force of the spring member compressed between the shaft head portion and the spring seat to thereby apply the spring force to the worm as the axial force.

19. A clamping device according to claim 18, wherein the spring member is a disc spring,

a "flexure-spring force" characteristic curve of the disc spring includes a region in which the spring force is substantially constant with respect to flexure variation, and the spring force in this region is applied to the worm as the axial force.

20. A clamping device according to claim 17, wherein the worm is elastically supported toward the initial position by a support

spring disposed on the same axis and

the worm is displaced from the initial position to the clamping force transmitting position against the support spring by the reaction force from the worm wheel due to the contact of the clamping arm with the workpiece.

21. A clamping device according to claim 20, wherein the contact sensor is for sensing that the worm has been displaced to the clamping force transmitting position.

22. A clamping device according to claim 20, wherein the support spring is a disc spring.